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Dept. of Environmental Quality
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Tank Management Bureau

**DATA VALIDATION AND STATISTICAL
EVALUATION OF JUNE 2016
GROUNDWATER QUALITY DATA
CITY OF HELENA LANDFILL**

Prepared For:

**CITY OF HELENA
HELENA, MONTANA**



Hydrometrics, Inc.
consulting scientists and engineers

AUGUST 2016

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EVALUATION OF JUNE 2016
GROUNDWATER QUALITY DATA**

CITY OF HELENA LANDFILL

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Dept. of Environmental Quality
Soils & Underground
Water Management Bureau

Prepared for:

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City/County Building
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August 2016



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August 23, 2016

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AUG 24 2016

Dept. of Environmental Quality
Waste & Underground
Tank Management Bureau

Mr. John Collins
Environmental Science Specialist
Solid Waste Regulatory Program
Montana Department of Environmental Quality
P.O. Box 200901
Helena, MT 59620-0901

RE: Data Validation and Statistical Evaluation of June 2016 Groundwater Quality Data

Dear John,

On behalf of the City of Helena, Hydrometrics validated and statistically evaluated groundwater quality data for samples collected at the City's municipal landfill in June 2016. After receiving approval from Pete Anderson of the City of Helena, I am forwarding a copy of the report 'Data Validation and Statistical Evaluation of June 2016 Groundwater Quality Data City of Helena Landfill' for your review.

If you have any questions concerning this report, please don't hesitate to call.

Sincerely,

Jodi Bingham, P.E.
Environmental Engineer/Chemist

Enclosure

- c: Randall Camp, City of Helena, without Enclosure
- Pete Anderson, City of Helena, without Enclosure
- Mike Wignot, Hydrometrics, without Enclosure

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**DATA VALIDATION AND STATISTICAL
EVALUATION OF JUNE 2016
GROUNDWATER QUALITY DATA
CITY OF HELENA LANDFILL**

1. REPORT OBJECTIVES

This report is prepared on behalf of the City of Helena Landfill to fulfill the groundwater data evaluation requirements provided in Administrative Rules, Montana (ARM) Title 17, Chapter 50. This report provides analytical results for groundwater samples collected at monitoring wells during the June 2016 monitoring event, summarizes, the data validation results and statistically evaluates the data. The samples were collected and analyzed in accordance with the Montana Department of Environmental Quality (MDEQ) approved sampling and analysis plan (Hydrometrics, 2008).

ARM 17.50.1305(8) and ARM 17.50.1305(9) stipulate the types of statistical data evaluations to be performed on groundwater quality monitoring data from regulated landfills. Federal guidance on conducting statistical evaluations of groundwater data is also available (EPA, 1989; EPA, 1992). These regulations and guidance documents allow the use of a wide range of statistical procedures including: parametric analysis of variance, non-parametric analysis of variance, tolerance or prediction interval testing, trend tests, or other statistical tests meeting the statistical testing objectives of the rules.

Statistical evaluations have been performed for this site semiannually since 1993 and the following conclusions have been reached based on the results of those evaluations:

- Chlorinated hydrocarbons occur downgradient of the landfill;
- Tetrachloroethene (PCE) is the chlorinated organic compound of greatest concern due to Maximum Contaminant Level (MCL) exceedances;

- These findings are further evaluated in this June 2016 statistical report through an assessment of current concentrations (Table 4-1), a comparison of summary statistics (Tables 4-2 and 4-3), an inter-well prediction analysis (Table 4-4), and an examination of temporal trends (Table 4-5 and Figures 4-1 and 4-2).

2. SITE DESCRIPTION

2.1 PHYSICAL FEATURES

A site location map is provided in Figure 2-1. The landfill is surrounded for several miles in all directions by residential, commercial and industrial zoned property. There are several businesses upgradient of the landfill, which have the potential to affect groundwater quality in the area.

A site plan is shown on Figure 2-2. The landfill is divided into three sections. The southern part of the landfill (Phase I and Phase II sections) is unlined and was in operation until the early 1980s. The northern part of the landfill (Phase III) is also unlined, and was in operation until November 1993. The Phase III landfill was capped with an 18-inch clay cover to minimize surface water percolation through the landfill and subsequent migration of chemicals into groundwater. Park improvements completed during 2011 added additional soil cover at varying depth over the majority of the landfill.

2.2 WELL LOCATIONS

Fourteen monitoring wells located around the landfill were included in the June 2016 groundwater monitoring program and are characterized as follows:

- Background wells: HL-06-1, HL-94-1R, HL-94-2R, MPC-5;
- Downgradient wells: HL-10-1 (replaced HL-90-1), HL-90-2, HL-90-3, MPC-1, MPC-2, EPA-1, HL-99-1, HL-99-2, HL-99-3; and
- Cross-gradient well: HL-94-3.

As discussed in Section 3.0 and in accordance with the approved sampling and analysis plan (Hydrometrics, 2008), all fourteen of these wells were sampled during the June sampling event. The locations of these wells are shown in Figure 2-2.



NO SCALE

CITY OF HELENA LANDFILL
DATA VALIDATION & STATISTICAL
EVALUATION OF JUNE 2016
GROUNDWATER QUALITY DATA

VICINITY MAP

FIGURE

2-1



SITE CODE	DTWL	MPE	SWL
Jun-16			
HL-06-1	18.48	3993.62	3975.14
82-3	66.48	3973.51	3907.03
EPA-1	47.80	3981.08	3933.28
EPA-2	dry	3981.286	
EPA-4	25.53	3973.83	3948.30
HL-10-1	55.33	3943.01	3887.68
HL-90-2	47.16	3950.96	3903.80
HL-90-3	59.51	3958.29	3898.78
HL-94-1R	59.17	3994.04	3934.87
HL-94-2R	35.88	3967.64	3931.76
HL-94-3	36.36	3967.38	3931.02
HL-99-1	60.51	3943.15	3882.64
HL-99-2	89.09	3945.75	3856.66
HL-99-3	64.57	3948.05	3883.48
INF. GALLE	9.81	3918.89	3909.08
I-1	59.59	3899.59	3840.00
MPC-1	23.12	3946.08	3922.96
MPC-2	17.53	3936.09	3918.56
MPC-5	57.67	3990.14	3932.47



SCALE

0 (In Feet) 800

LEGEND

- L-1 ■ PIEZOMETER
- 3-6 ● MONITORING WELL
- 1-6 ▲ IRRIGATION WELL
- 80 □ DOMESTIC WELL
- INFILTRATION GALLERY (GROUNDWATER COLLECTION SYSTEM)
- AREA OF SHALLOW LOW PERMEABILITY BEDROCK
- POTENTIOMETRIC CONTOUR LINE
- INFERRED GROUNDWATER FLOW DIRECTION
- STORM WATER OUTFALL FOR LAST CHANCE GULCH

STUDY AREA AND JUNE 2016
POTENTIOMETRIC SURFACE

FIGURE

2-2



SITE CODE	DTWL	MPE	SWL
Jun-16			
HL-06-1	18.48	3993.62	3975.14
82-3	66.48	3973.51	3907.03
EPA-1	47.80	3981.08	3933.28
EPA-2	dry	3981.286	
EPA-4	25.53	3973.83	3948.30
HL-10-1	55.33	3943.01	3887.68
HL-90-2	47.16	3950.96	3903.80
HL-90-3	59.51	3958.29	3898.78
HL-94-1R	59.17	3994.04	3934.87
HL-94-2R	35.88	3967.64	3931.76
HL-94-3	36.36	3967.38	3931.02
HL-99-1	60.51	3943.15	3882.64
HL-99-2	89.09	3945.75	3856.66
HL-99-3	64.57	3948.05	3883.48
INF. GALLE	9.81	3918.89	3909.08
I-1	59.59	3899.59	3840.00
MPC-1	23.12	3946.08	3922.96
MPC-2	17.53	3936.09	3918.56
MPC-5	57.67	3990.14	3932.47



- LEGEND**
- HL-1 ■ PIEZOMETER
 - E3-6 ● MONITORING WELL
 - I-6 ▲ IRRIGATION WELL
 - 80 □ DOMESTIC WELL
 - INFILTRATION GALLERY (GROUNDWATER COLLECTION SYSTEM)
 - AREA OF SHALLOW LOW PERMEABILITY BEDROCK
 - 3900 — POTENTIOMETRIC CONTOUR LINE
 - INFERRED GROUNDWATER FLOW DIRECTION
 - ↘ STORM WATER OUTFALL FOR LAST CHANCE GULCH

CITY OF HELENA LANDFILL
DATA VALIDATION & STATISTICAL
EVALUATION OF JUNE 2016
GROUNDWATER QUALITY DATA

STUDY AREA AND JUNE 2016
POTENTIOMETRIC SURFACE

FIGURE
2-2

2.3 GROUNDWATER STATIC WATER LEVELS, FLOW DIRECTION AND VELOCITY

Static water levels were measured at eighteen monitoring wells (wells 82-3, EPA-2, EPA-4, and I-1 in addition to the fourteen wells listed in Section 2.2) as part of the June 2016 monitoring event. Water levels were measured at a designated monitoring point using an electric water level probe and all depth to water level measurements were recorded in the project notebook and on field forms included in Appendix A.

Figure 2-2 shows water level elevations observed in June 2016 and groundwater potentiometric surface contours. Groundwater flow direction is also shown on this figure. The general groundwater flow direction in the vicinity of the landfill is to the north-northwest. The potentiometric surface in the area of well HL-94-3 suggests that groundwater flows to the west northwest (Figure 2-2); thus, well HL-94-3 is not considered to be upgradient or downgradient of the landfill. Well HL-94-3 has, therefore, been designated as a “cross-gradient” well. Figure 2-3 shows the last ten years of hydrographs for the fourteen monitoring wells sampled. All June 2016 groundwater elevations were within the historic range.

Table 2-1 shows the groundwater velocities calculated for each of the monitoring wells sampled during the June 2016 sampling event. Slope was determined from the potentiometric contours shown in Figure 2-2. The hydraulic conductivities were obtained from the groundwater flow model inputs included in the report “Evaluation of Groundwater Extraction Remediation Alternative at the Helena Landfill” (Hydrometrics, 1999a). The porosity for each well was assumed to be 0.25. An average regional gradient of 0.0225 ft/ft was determined between monitoring well HL-06-1 and I-1. Using an average hydraulic conductivity of 7.4 ft/day, this yields an average regional velocity of 0.666 ft/day.

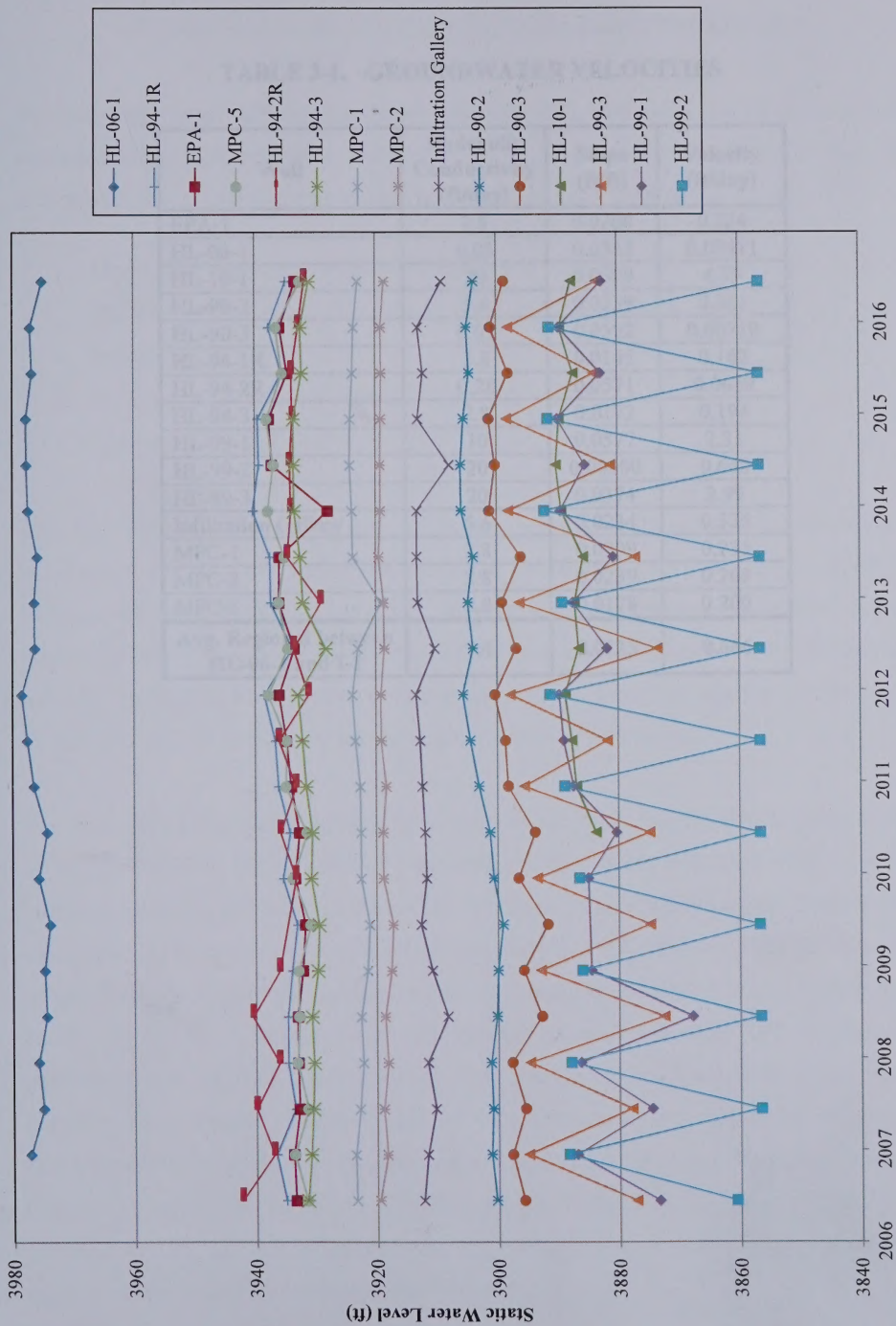


Figure 2-3. Groundwater Hydrographs

TABLE 2-1. GROUNDWATER VELOCITIES

Well	Hydraulic Conductivity (ft/day)	Slope (ft/ft)	Velocity (ft/day)
EPA-1	2.8	0.0200	0.224
HL-06-1	0.03	0.0342	0.00411
HL-10-1	20	0.0599	4.79
HL-90-2	5.6	0.0259	0.581
HL-90-3	0.03	0.0592	0.00710
HL-94-1R	2.8	0.0145	0.162
HL-94-2R	0.28	0.0571	0.0640
HL-94-3	2.8	0.0173	0.194
HL-99-1	10	0.0577	2.31
HL-99-2	20	0.00800	0.640
HL-99-3	20	0.0374	2.99
Infiltration Gallery	5.6	0.0234	0.525
MPC-1	2.8	0.0209	0.235
MPC-2	2.8	0.0239	0.268
MPC-5	2.8	0.0178	0.200
Avg. Regional between HL-06-1 and I-1	7.4	0.0225	0.666

3. SUMMARY OF JUNE 2016 DATA VALIDATION REPORT

Fourteen monitoring wells around the landfill, eight domestic wells, one irrigation well and the infiltration gallery well were included in the June 2016 sampling event. The June 2016 monitoring sites for the City of Helena Landfill include the following:

- Monitoring wells EPA-1, HL-06-1, HL-10-1, HL-90-2, HL-90-3, HL-94-1R, HL-94-2R, HL-94-3, HL-99-1, HL-99-2, HL-99-3, MPC-1, MPC-2, MPC-5;
- Irrigation well I-4;
- Domestic wells 5, 16, 40, 48, 52, 57, 62, 90; and
- The infiltration gallery.

The June analytical parameters included metals, volatile organics, semi-volatile organics, halogenated organics, and major anions for the infiltration gallery and all the monitoring wells except MPC-2. Volatile organics, semi-volatile organics, and halogenated organics were analyzed for samples collected from MPC-2 and all remaining domestic and irrigation wells as specified in the approved sampling and analysis plan (Hydrometrics, 2008). Wells 52 and 90 could not be sampled due to access issues with landowners.

The water samples collected for the City of Helena Landfill in June 2016 have been validated by the Hydrometrics Data Validation Department in accordance with the project work plan, "Revised Sampling and Analysis Plan, City of Helena Landfill, Groundwater, Surface Water and Landfill Gas Monitoring Activities" (Hydrometrics, 2008). Lab and field quality control procedures were appropriate; quality control (QC) samples included a field duplicate, a D.I. blank, trip blanks, a rinsate blank, and standard internal laboratory QC samples. No parameters were reported as above the reporting limit in the D.I. blank, rinsate blank or trip blanks. Two samples (HL-99-2 and MPC-5) were analyzed outside of the method recommended holding time for cyanide by 0.875 days and 0.170 days, respectively, and were flagged by the lab. The entire data validation report is included as Appendix A of this report. Overall, the City of Helena Landfill data for June 2016 were deemed acceptable for the purposes of the project as outlined in the work plan.

4. STATISTICAL DATA EVALUATION AND COMPARISON

Four types of data evaluations were conducted using the June 2016 sample results for the monitoring wells around the landfill; cross-gradient well HL-94-3 is evaluated separately. The infiltration gallery, irrigation well, and domestic wells are also evaluated separately. The four types of data evaluations conducted are:

1. Comparisons of applicable water quality criteria and upgradient (also called “background”) water quality with summary statistics of downgradient concentrations for June 2016 and all samples to date;
2. Inter-well prediction interval analysis;
3. Trend analysis; and
4. Temporal concentration plots.

The first three analyses include all those parameters for which results were reported above the detection limit in any of the monitoring wells for the June 2016 sampling event. Due to the decrease in laboratory detection limits for many of the parameters, more parameters are included in these tables than historically shown.

The fourth evaluation, temporal concentration plots, was performed for PCE and nitrate; the only constituents that currently exceed their regulatory limits in downgradient wells. Data from all wells sampled during the June 2016 sampling event, which have historically shown PCE results above the detection limit or nitrate results above the MCL of 10 mg/L or with potentially increasing PCE or nitrate trends were evaluated.

4.1 DOWNGRADIENT WATER QUALITY COMPARISONS WITH CRITERIA AND UPGRADIENT WATER QUALITY

The following conclusions are derived from the June 2016 data and summary statistics in Tables 4-1, 4-2, and 4-3:

- (a) For the June 2016 sampling event (Tables 4-1 and 4-2), the following parameters were detected only in background (or upgradient) wells: antimony, benzene, chloro-

methane, toluene, 1,1,1-trichloroethane, m+p xylene, o-xylene, and total xylene. Parameters detected in only downgradient wells include: zinc, cis-1,2-dichloroethene, dichlorodifluoro-methane, 1,1-dichloroethane, 1,2-dichloropropane, tetrachloroethene (PCE), trichloroethene (TCE), and trichlorofluoromethane.

- (b) The parameters historically detected only in downgradient wells (Table 4-3) are: cis-1,2-dichloroethene, dichlorodifluoromethane, 1,1-dichloroethane, 1,2-dichloropropane, TCE, and trichlorofluoromethane. There were no parameters historically detected in only background wells.
- (c) Cyanide, nitrate, arsenic, iron, benzene, and PCE were reported at concentrations exceeding MCL criteria in the June 2016 sampling event (Tables 4-1 and 4-2). The MCLs for cyanide and benzene were exceeded in a single upgradient well (MPC-5); the MCL for arsenic was exceeded in a single upgradient well (HL-94-2R); the MCL for PCE was exceeded in three downgradient wells (HL-10-1, MPC-1, and HL-99-3); nitrate exceeded its MCL in five downgradient wells (HL-90-3, EPA-1, MPC-1, HL-99-1, and HL-10-1), two upgradient wells (HL-94-1R and MPC-5), and cross-gradient well HL-94-3; the secondary MCL (based on aesthetic properties rather than human health standards) for iron was exceeded in a single upgradient well (MPC-5).
- (d) Historically in these wells, cyanide, nitrate, antimony, arsenic, cadmium, iron, benzene, PCE, and TCE have been reported at concentrations exceeding MCL criteria (Table 4-3). The MCLs for cadmium, PCE, and TCE have been exceeded in only downgradient wells; cyanide, nitrate, antimony, arsenic, and iron have exceeded their MCLs in both upgradient and downgradient wells; and the MCL for benzene has been exceeded in only upgradient wells. The June 2016 data is generally consistent with these trends.
- (e) Nitrate was detected in all of the June 2016 samples. The MCL of 10.0 mg/L was exceeded in two samples collected in upgradient wells (HL-94-1R and MPC-5), cross-gradient well HL-94-3, and in five samples collected from downgradient wells (HL-90-3, EPA-1, MPC-1, HL-99-1, and HL-10-1). Monitoring well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 73.0 mg/L. Since then, there has been a general decrease in the nitrate concentration in this well and is

TABLE 4-1. SUMMARY OF PARAMETER CONCENTRATIONS IN LANDFILL MONITORING WELLS
FOR THE JUNE 2016 MONITORING EVENT

Parameter	Downgradient Wells										Upgradient Wells			Cross-Gradient	MCL ⁽¹⁾
	HL-90-2	HL-90-3	EPA-1	MPC-1	MPC-2	HL-99-1	HL-99-2	HL-99-3	HL-10-1	HL-06-1	HL-94-1R	HL-94-2R	MPC-3	HL-94-3	
pH (s.u.)	7.6	7.2	6.8	7.1	NM	7.2	7.4	7.3	7.1	7.1	7.4	7.6	7.1	7.6	NA
Specific Conductance (µmhos/cm)	763	1410	2330	1190	NM	1360	880	1000	1390	991	1250	978	2510	1100	NA
Chloride	27	76	169	61	NM	88	41	51	101	36	46	57	32	92	NA
Sulfate	64	214	317	220	NM	190	115	162	188	81	139	67	382	172	NA
Cyanide (Total)	< 0.003	< 0.003	< 0.003	0.042	NM	< 0.003	0.005	0.024	< 0.003	< 0.003	< 0.003	< 0.003	1.70	0.012	0.2
Chemical Oxygen Demand (COD)	< 4	0	15	< 4	NM	< 4	< 4	< 4	< 4	< 4	9	5	61	< 4	NA
Nitrate-Nitrite as N	2.6	16.7	18.8	11.7	NM	10.5	2.61	8.3	10.1	1.91	13.8	8.0	31.0	15.6	10
Antimony (Dissolved)	< 0.0005	< 0.0005	< 0.0005	< 0.0005	NM	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0008	< 0.0005	0.006
Arsenic (Dissolved)	0.001	0.001	< 0.001	0.001	NM	0.001	0.001	0.001	< 0.001	0.002	0.002	0.012	0.004	< 0.001	0.010
Barium (Dissolved)	0.035	0.050	0.077	0.058	NM	0.076	0.045	0.047	0.082	0.052	0.069	0.038	0.048	0.081	1.0
Cadmium (Dissolved)	< 0.00003	< 0.00003	0.00004	< 0.00003	NM	< 0.00003	< 0.00003	< 0.00003	< 0.00003	< 0.00003	0.00006	< 0.00003	0.00013	< 0.00003	0.005
Copper (Dissolved)	< 0.002	< 0.002	< 0.002	< 0.002	NM	< 0.002	0.003	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.003	< 0.002	1.3
Iron (Dissolved)	< 0.02	< 0.02	0.05	0.03	NM	< 0.02	< 0.02	< 0.02	0.03	< 0.02	< 0.02	< 0.02	0.46	< 0.02	0.3 (2)
Mercury (Dissolved)	< 0.000005	< 0.000005	< 0.000005	0.000013	NM	0.0000235	0.000122	0.0000474	0.0000259	< 0.000005	< 0.000005	< 0.000005	0.0000107	< 0.000005	0.002
Nickel (Dissolved)	< 0.002	< 0.002	0.028	< 0.002	NM	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.008	< 0.002	0.10
Selenium (Dissolved)	< 0.001	0.004	< 0.001	0.001	NM	0.001	< 0.001	< 0.001	< 0.001	0.001	0.011	0.005	0.013	< 0.001	0.05
Zinc (Dissolved)	0.008	< 0.008	< 0.008	< 0.008	NM	< 0.008	0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	2.0
Benzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	NM	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	2.36	< 0.0005	0.005
Chloroform	< 0.0005	0.0053	< 0.0005	0.0023	< 0.0005	0.0016	< 0.0005	< 0.0005	< 0.0005	0.00056	0.013	0.0017	0.0048	0.0042	0.07
Chloromethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0026	< 0.0005	0.03
Cis-1,2-Dichloroethane	< 0.0005	< 0.0005	0.0093	0.0054	0.0012	0.0021	0.00078	0.0015	0.0027	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.07
Dichlorodifluoromethane	< 0.0005	< 0.0005	< 0.0005	0.00076	< 0.0005	0.00070	0.0010	0.0014	0.0013	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	NA
1,1-Dichloroethane	< 0.0005	< 0.0005	< 0.0005	0.0028	< 0.0005	0.00074	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.005
1,2-Dichloroethane	< 0.0005	< 0.0005	0.00072	< 0.0005	< 0.0005	< 0.0005	0.0026	0.0072	0.0061	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.2
1,2-Dichloropropane	< 0.0005	< 0.0005	0.0023	0.0062	< 0.0005	0.0029	0.0026	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	1.0
Tetrachloroethene (PCE)	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.005
Toluene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0020	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.005
1,1,1-Trichloroethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.00079	0.00073	0.0014	0.0019	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.005
Trichloroethene (TCE)	< 0.0005	< 0.0005	< 0.0005	0.0019	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	10
Trichlorofluoromethane	< 0.0005	< 0.0005	< 0.0005	0.0086	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	10 (3)
M-PP Xylene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.0024	< 0.001	10 (3)
O-Xylene	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.167	< 0.001	10 (3)
Total Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.192	< 0.0005	1.0

Concentrations are in mg/L, except as indicated.

NM = not measured

(1) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking

water supplies. NA indicates no MCL has been promulgated.

(2) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(3) MCL is for Total Xylenes

Values in bold exceed the MCL.

TABLE 4-2. COMPARISON OF DOWNGRADIENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS AND MCLs FOR THE JUNE 2016 SAMPLING EVENT

Parameter	June 2016 Downgradient Well Concentrations (mg/L) ⁽¹⁾					Comparison Values (mg/L)				
	D.F. ⁽³⁾	Min.	Mean ⁽⁴⁾	Median	Max.	Max. Location	D.F. ⁽³⁾	Background / Upgradient Wells ⁽²⁾	Median	MCL ⁽⁵⁾
								Mean ⁽⁴⁾		
pH (s.u.)	8/8	6.8	7.21	7.2	7.6	HL-90-2	4/4	7.30	7.3	NA
Specific Conductance (µmhos/cm)	8/8	763	1315	1275	2530	EPA-1	4/4	1432	1121	NA
Chloride	8/8	27	76.8	68.5	169	EPA-1	4/4	41.0	41	57
Sulfate	8/8	64	183.8	189	317	EPA-1	4/4	217.3	110	582
Cyanide (Total)	3/8	< 0.003	0.011	< 0.003	0.042	MPC-1	1/4	0.43	< 0.003	1.7
Chemical Oxygen Demand (COD)	2/8	< 4	5.6	< 4	15	EPA-1	3/4	19.8	7	NA
Nitrate-Nitrite as N	8/8	2.6	9.41	10.3	18.8	EPA-1	4/4	13.68	10.9	31
Antimony (Dissolved)	0/8	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1/4	0.0006	< 0.0005	0.0006
Arsenic (Dissolved)	6/8	< 0.001	0.001	0.0010	0.001	HL-90-2	4/4	0.0050	0.003	0.012
Barium (Dissolved)	8/8	0.035	0.059	0.054	0.082	HL-10-1	4/4	0.052	0.050	1.0
Cadmium (Dissolved)	1/8	< 0.00003	0.000031	< 0.0000	0.00004	EPA-1	2/4	0.000063	0.000045	0.00013
Copper (Dissolved)	1/8	< 0.002	0.0021	< 0.002	0.003	HL-99-2	1/4	0.0023	< 0.002	0.003
Iron (Dissolved)	3/8	< 0.02	0.026	< 0.02	0.05	EPA-1	1/4	0.13	< 0.02	0.46
Mercury (Dissolved)	5/8	< 0.000005	0.00000309	0.00000184	0.0000122	HL-99-2	1/4	0.0000064	< 0.000005	0.000011
Nickel (Dissolved)	1/8	< 0.002	0.0053	< 0.002	0.0280	EPA-1	1/4	0.0035	< 0.002	0.008
Selenium (Dissolved)	3/8	< 0.001	0.0014	< 0.001	0.004	HL-90-3	4/4	0.0075	0.008	0.013
Zinc (Dissolved)	2/8	< 0.008	0.0080	< 0.008	0.008	HL-90-2	0/4	< 0.0080	< 0.008	2.0
Benzene	0/9	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1/4	0.5904	< 0.0005	2.36
Chloroform	6/9	< 0.0005	0.0016	0.0010	0.0053	HL-90-3	4/4	0.0050	0.00325	0.013
Chloromethane	0/9	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1/4	0.0010	< 0.0005	0.026
Cis-1,2-Dichloroethene	7/9	< 0.0005	0.0027	0.0015	0.0093	EPA-1	0/4	< 0.0005	< 0.0005	0.07
Dichlorodifluoromethane	5/9	< 0.0005	0.00080	0.00070	0.0014	HL-99-3	0/4	< 0.0005	< 0.0005	1.0
1,1-Dichloroethane	6/9	< 0.0005	0.0014	0.00085	0.0029	HL-99-3	0/4	< 0.0005	< 0.0005	NA
1,2-Dichloropropane	1/9	< 0.0005	0.0052	< 0.0005	0.0072	EPA-1	0/4	< 0.0005	< 0.0005	0.005
Tetrachloroethene (PCE)	7/9	< 0.0005	0.0033	0.0026	0.0072	HL-99-3	0/4	< 0.0005	< 0.0005	0.005
Toluene	0/9	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1/4	0.0016	< 0.0005	1.0
1,1,1-Trichloroethane	0/9	< 0.0005	< 0.0005	< 0.0005	< 0.0005	MPC-1	0/4	< 0.0005	< 0.0005	0.2
Trichloroethene (TCE)	6/9	< 0.0005	0.0010	0.00073	0.0019	MPC-1	0/4	< 0.0005	< 0.0005	0.005
Trichlorofluoromethane	1/9	< 0.0005	0.0054	< 0.0005	0.0086	MPC-1	0/4	< 0.0005	< 0.0005	10
M+P Xylene	0/9	< 0.001	< 0.001	< 0.001	< 0.001	N/A	1/4	0.0014	< 0.001	0.024
O-Xylene	0/9	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1/4	0.042	< 0.0005	0.167
Total Xylene	0/9	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1/4	0.048	< 0.0005	0.192

- (1) Downgradient wells are: HL-90-2, HL-90-3, EPA-1, MPC-1, HL-99-1, HL-99-2, HL-99-3, HL-10-1.
(2) Background / Upgradient wells are: HL-06-1, HL-94-1R, HL-94-2R, MPC-5.
(3) Detection frequency (D.F.), i.e. the number of detections over the total number of samples analyzed for that parameter.
(4) Means calculated using the detection limit for non-detected sample results.
(5) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking water supplies.
NA indicates no MCL has been promulgated.
(6) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.
(7) MCL is for Total Xylenes

Values in bold exceed the MCL. Underlined values exceed the maximum background/upgradient concentration.

TABLE 4-3. COMPARISON OF DOWNGRADEMENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS AND MCLs FOR ALL SAMPLING EVENTS TO DATE

Parameter	Period of Record Downgradient Well Concentrations (mg/L) ⁽¹⁾					Comparison Values (mg/L)					
	D.F. ⁽³⁾	Min.	Mean ⁽⁴⁾	Median	Max. Location	Background / Upgradient Wells ⁽²⁾			MCL ⁽⁵⁾		
						D.F. ⁽³⁾	Mean ⁽⁴⁾	Median		Max.	
pH (s.u.)	313 / 313	6.8	7.39	7.4	8.1	HL-90-2	161 / 161	7.41	7.5	8.1	NA
Specific Conductance (umhos/cm)	303 / 303	632	1098	1020	2550	EPA-1	157 / 157	1402	1030	4170	NA
Chloride	313 / 313	2	60.8	47	262	EPA-1	160 / 161	44.4	30	250	NA
Sulfate	312 / 313	< 15	141	140	345	EPA-1	161 / 161	264	100	1980	NA
Cyanide (Total)	92 / 313	< 0.003	0.014	< 0.005	0.40	HL-99-2	38 / 163	1.1	< 0.005	10.9	0.2
Chemical Oxygen Demand (COD)	209 / 311	< 0.3	4.3	3.0	26	EPA-1	133 / 161	13.2	8.0	75	NA
Nitrate-Nitrite as N	290 / 292	< 0.05	7.8	8.3	19.1	EPA-1	156 / 156	10.8	7.1	73	10
Antimony (Dissolved)	4 / 293	< 0.0005	0.023	< 0.005	0.05	EPA-1	3 / 159	0.022	< 0.005	0.05	0.006
Arsenic (Dissolved)	46 / 313	< 0.001	0.0047	< 0.005	0.028	MPC-2	75 / 164	0.0064	< 0.005	0.10	0.010
Barium (Dissolved)	61 / 313	0.032	0.094	< 0.1	0.2	MPC-2	28 / 164	0.092	< 0.1	0.10	1.0
Cadmium (Dissolved)	19 / 316	< 0.0003	0.0009	< 0.001	0.006	HL-90-3	13 / 164	0.00087	< 0.001	0.0020	0.005
Copper (Dissolved)	10 / 296	< 0.002	0.0088	< 0.01	0.01	EPA-1	8 / 159	0.0089	< 0.01	0.02	1.3
Iron (Dissolved)	75 / 313	< 0.02	0.073	< 0.03	1.69	MPC-1	55 / 161	0.32	< 0.03	3.14	0.3 (6)
Mercury (Dissolved)	37 / 313	< 0.000005	0.00086	< 0.001	0.0010	EPA-1	9 / 164	0.00085	< 0.001	0.001	0.002
Nickel (Dissolved)	30 / 293	< 0.002	0.010	< 0.01	0.06	EPA-1	31 / 159	0.010	< 0.01	0.050	0.10
Selenium (Dissolved)	23 / 313	< 0.001	0.0045	< 0.005	0.06	HL-90-3	66 / 164	0.0056	< 0.005	0.027	0.05
Zinc (Dissolved)	39 / 296	< 0.008	0.0128	< 0.01	0.150	HL-90-2	14 / 159	0.0105	< 0.01	0.10	2.0
Benzene	2 / 441	< 0.00005	0.00093	< 0.001	0.0029	HL-90-2	37 / 168	0.0071	< 0.001	4.65	0.005
Chloroform	302 / 441	< 0.0005	0.0023	0.002	0.016	EPA-1	131 / 168	0.0056	0.0028	0.037	0.07
Chloroethane	2 / 441	< 0.0005	0.00095	< 0.001	0.002	HL-99-1	2 / 167	0.0010	< 0.001	0.0036	0.03
Cis-1,2-Dichloroethene	147 / 418	< 0.0005	0.0014	< 0.001	0.011	EPA-1	0 / 163	< 0.001	< 0.001	< 0.001	0.07
Dichlorodifluoromethane	194 / 441	0.00047	0.0015	< 0.001	0.016	EPA-1	0 / 168	< 0.001	< 0.001	< 0.001	1
1,1-Dichloroethane	276 / 441	< 0.0005	0.0020	0.0014	0.0073	MPC-1	0 / 168	< 0.001	< 0.001	< 0.001	NA
1,2-Dichloropropane	16 / 424	< 0.0005	0.0010	< 0.001	0.0046	EPA-1	0 / 163	< 0.001	< 0.001	< 0.001	0.005
Tetrachloroethene (PCE)	326 / 441	< 0.0005	0.00636	0.0044	0.094	EPA-1	1 / 168	0.00092	< 0.001	0.0010	0.005
Toluene	16 / 441	< 0.0005	0.0010	< 0.001	0.0094	MPC-2	15 / 168	0.0011	< 0.001	0.015	1.0
1,1,1-Trichloroethane	57 / 441	< 0.0002	0.0011	< 0.001	0.0074	HL-90-1	24 / 168	0.0012	< 0.001	0.0057	0.2
Trichloroethene (TCE)	202 / 441	< 0.0005	0.0013	< 0.001	0.0074	EPA-1	0 / 168	< 0.001	< 0.001	< 0.001	0.005
Trichlorofluoromethane	69 / 441	< 0.0003	0.0011	< 0.001	0.0083	EPA-1	0 / 168	< 0.001	< 0.001	< 0.001	10
M+P Xylene	1 / 413	< 0.001	0.0010	< 0.001	0.002	HL-99-1	35 / 163	0.0064	< 0.001	0.508	10 (7)
O-Xylene	3 / 416	< 0.0005	0.0009	< 0.001	0.002	HL-99-1	37 / 163	0.0096	< 0.001	0.422	10 (7)
Total Xylene	1 / 210	< 0.0005	0.00088	< 0.001	0.002	MPC-2	20 / 88	0.024	< 0.001	0.93	10

(1) Downgradient wells are: HL-10-1, HL-90-1, HL-90-2, HL-90-3, MPC-1, MPC-2, EPA-1, HL-99-1, HL-99-2, HL-99-3.

(2) Background / Upgradient wells are: 83-6, HL-06-1, MPC-5, HL-94-1, HL-94-1R, HL-94-2, HL-94-2R.

(3) Detection frequency (D.F.), i.e. the number of detections over the total number of samples analyzed for that parameter.

(4) Means calculated using the detection limit for non-detected sample results.

(5) Primary Maximum Contaminant Levels promulgated under the Safe Drinking Water Act for protection of public drinking water supplies.

NA indicates no MCL has been promulgated.

(6) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(7) MCL is for Total Xylenes

Values in bold exceed the MCL. Underlined values exceed the maximum background/upgradient concentration.

currently at a level of 31.0 mg/L. Discussions with MPC representatives revealed that an attempt to remediate cyanide (from a historic coal gasification plant that was operated just east of the landfill) through oxidation may have inadvertently increased nitrate concentration in area groundwater. This pilot program was shut down when these adverse effects became apparent. However, nitrate levels in wells downgradient of the MPC site have slowly been increasing since that time.

- (f) Metals and arsenic concentrations in groundwater samples have historically been low (typically below laboratory detection limits). With the decreased laboratory detection limits, the number of detections has increased both upgradient and downgradient of the landfill. The detected arsenic and metal concentrations were all at or near their detection limits except for arsenic in upgradient well HL-94-2R (0.012 mg/L) compared to a detection limit of 0.001 mg/L; barium in all wells (ranging from 0.035 to 0.082 mg/L) compared to a detection limit of 0.003 mg/L; cadmium (0.00013 mg/L) and iron (0.46 mg/L) in upgradient well MPC-5 compared to detection limits of 0.00003 mg/L and 0.02 mg/L, respectively; mercury in downgradient wells MPC-1 (0.000013 mg/L), HL-99-1 (0.0000235 mg/L), HL-99-2 (0.000122 mg/L), HL-99-3 (0.0000474 mg/L) and HL-10-1 (0.0000259 mg/L) and upgradient well MPC-5 (0.0000107) compared to a detection limit of 0.000005 mg/L; nickel in downgradient well EPA-1 (0.028 mg/L) compared to a detection limit of 0.002 mg/L; and selenium in upgradient wells HL-94-1 (0.011 mg/L) and MPC-5 (0.013 mg/L) compared to a detection limit of 0.001 mg/L. All barium, cadmium, mercury, nickel, and selenium detections were all well below their respective MCLs. Arsenic exceeded the MCL of 0.01 mg/L in upgradient well HL-94-2R. Arsenic has historically fluctuated at HL-94-2 with concentrations ranging from <0.005 mg/L to 0.011 mg/L (based on data collected from April 1994 through December 2015) and reached a new high of 0.012 mg/L in the June 2016 sampling event. Iron exceeded the secondary MCL of 0.3 mg/L (based on aesthetic properties such as taste, odor and staining rather than human health standards) in MPC-5. Iron has historically fluctuated at MPC-5 with concentrations ranging from approximately 0.2 mg/L to 4 mg/L (based on data collected from December 1995 through June 2016).

(g) During the June 2016 sampling event, several volatile organic compounds (VOCs) were detected in samples from downgradient wells, but not in samples from background wells (cis-1,2-dichloroethene, dichlorodifluoromethane, 1,1-dichloroethane, 1,2-dichloropropane, PCE, TCE, and trichlorofluoro-methane). PCE was the only VOC to exceed its MCL in downgradient wells (HL-10-1, MPC-1, and HL-99-3). Benzene, chloromethane, toluene, 1,1,1-trichloro-ethane, m+p xylene, o-xylene, and total xylene were detected only in background wells; benzene was the only VOC to exceed its MCL in upgradient wells (MPC-5). Chloroform was detected in samples from both downgradient and background wells. All detections of chloroform were well below the MCL of 0.07 mg/L.

(h) Cyanide was detected in three downgradient wells (MPC-1, HL-99-2, and HL-99-3) and one upgradient well (MPC-5) during the June 2016 sampling event. The cyanide MCL of 0.2 mg/L was exceeded in upgradient well MPC-5 (1.70 mg/L). Previous sampling events have shown that cyanide is present at concentrations ranging from approximately 0.20 to 11 mg/L (based on data collected from June 1995 through June 2016) in upgradient well MPC-5. Historically, downgradient detections of cyanide have been well below the MCL indicating that elevated cyanide levels are not attributable to the Helena Landfill (Table 4-3). As noted previously, a coal gasification plant was historically operated east of the landfill site and could be a source of residual cyanide in groundwater upgradient of the landfill.

4.2 INTER-WELL PREDICTION INTERVAL ANALYSIS

An inter-well prediction interval analysis was used to test for statistically significant differences between background and compliance well concentrations for selected parameters (those above the detection limit in any of the monitoring wells for the June 2016 sampling event). Combining all historical data for the background wells, the Shapiro-Francia Test of Normality was performed for each parameter to determine the distribution of the background data. For metals data, if previous detection limits were significantly less than the current detection limit and all results of previous sampling events were below the detection limit, then only the results of the most recent testing (June 2013 to present) were used for analysis. Inter-well parametric prediction intervals were used when the background data were

normally or ln-normally distributed. In cases where the background data were not normally or ln-normally distributed, a non-parametric prediction limit was used. All non-detect values were evaluated at one-half the detection limit. Results of the prediction interval test are summarized in Table 4-4. Documentation for each of these statistical tests used is included in Appendix B of this report.

As shown on Table 4-4, mercury, cis-1,2-dichloroethane, dichlorodifluoro-methane, 1,1-dichloroethane, 1,2-dichloropropane, PCE, TCE, and trichlorofluoromethane have statistically greater concentrations in downgradient wells than upgradient wells.

4.3 TREND ANALYSIS

In addition to evaluating the chemical concentrations in upgradient and downgradient wells around the landfill for the June 2016 sampling event, it is also important to evaluate concentration trends of key constituents over time. Using the Mann-Kendall test, statistical testing for trends was performed for each downgradient exceedance of its respective inter-well prediction interval as discussed in Section 4.2. All non-detect values were evaluated as zero to prevent the detection of false trends when parameters are detected at concentrations less than the reporting limit or when the reporting limits have changed over time. The results of these analyses are summarized in Table 4-5. Documentation for these statistical tests is included in Appendix B of this report.

Results show increasing trends in cis-1,2-dichloroethene in well MPC-1, MPC-2, HL-99-2, HL-99-3, and HL-10-1; 1,1-dichloroethane in wells HL-99-2 and HL-10-1; PCE in well MPC-2; and TCE in wells MPC-2, HL-99-1, HL-99-2, and HL-10-1. According to National Primary Drinking Water Regulations, cis-1,2-dichloroethane is formed as a breakdown product of the common industrial solvents TCE and PCE. Although there are several wells with increasing trends of cis-1,2-dichloroethane, all detections are wells below the MCL of 0.07 mg/L. 1,1-Dichloroethane is a breakdown product of 1,1,1-trichloroethane, historically found primarily in wells upgradient of the Helena landfill. There is no MCL for 1,1-dichloroethane. TCE is an industrial solvent. Although there are several wells with

TABLE 4-4. RESULTS OF INTER-WELL PREDICTION INTERVAL TESTS

Parameter	Background Wells		Downgradient Wells								
	Distribution	⁽¹⁾ Prediction Limit ⁽³⁾ 6.9-7.9	HL-90-2	HL-90-3	EPA-1	MPC-1	MPC-2	HL-99-1	HL-99-2	HL-99-3	HL-10-1
pH (s.u.)	Non-Norm	3880	7.6	7.2	6.8	7.1	NM	7.2	7.4	7.3	7.1
Specific Conductance (µmhos/cm)	Non-Norm	180	763	1410	2530	1190	NM	1360	880	1000	1390
Chloride	Non-Norm	1554	27	76	169	61	NM	88	41	51	101
Sulfate	Non-Norm	1554	64	214	317	220	NM	190	115	162	188
Cyanide (Total)	Non-Norm	10.5	0.003	0.003	0.003	0.042	NM	0.003	0.005	0.024	0.003
Chemical Oxygen Demand (COD)	Non-Norm	67.2	4	6	15	4	NM	4	4	4	4
Nitrate+Nitrite as N	Non-Norm	61.4	2.6	10.7	18.8	11.7	NM	10.5	2.61	8.3	10.1
Antimony (Dissolved)	Non-Norm	0.00075	0.0005	0.0005	0.0005	0.0005	NM	0.0005	0.0005	0.0005	0.0005
Arsenic (Dissolved)	Non-Norm	0.046	0.001	0.001	0.001	0.001	NM	0.001	0.001	0.001	0.001
Barium (Dissolved)	Norm-95%	0.10	0.035	0.05	0.077	0.058	NM	0.076	0.045	0.047	0.082
Cadmium (Dissolved)	Non-Norm	0.00013	0.00003	0.00003	0.00004	0.00003	NM	0.00003	0.00003	0.00003	0.00003
Copper (Dissolved)	Non-Norm	0.0030	0.002	0.002	0.002	0.002	NM	0.002	0.003	0.002	0.002
Iron (Dissolved)	Non-Norm	2.83	0.02	0.02	0.05	0.03	NM	0.02	0.02	0.02	0.03
Mercury (Dissolved)	Non-Norm	0.0000286	0.000005	0.000005	0.000005	0.0000133	NM	0.0000235	0.000122	0.0000474	0.0000259
Nickel (Dissolved)	Non-Norm	0.039	0.002	0.002	0.028	0.002	NM	0.002	0.002	0.002	0.002
Selenium (Dissolved)	Norm-95%	0.017	0.001	0.004	0.001	0.001	NM	0.001	0.001	0.001	0.001
Zinc (Dissolved)	Non-Norm	0.024	0.008	0.008	0.008	0.008	NM	0.008	0.008	0.008	0.008
Benzene	Non-Norm	1.69	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Chloroform	Non-Norm	0.035	0.0005	0.0053	0.0005	0.0023	0.0005	0.0016	0.001	0.0022	0.00063
Chloromethane	Non-Norm	0.0017	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Cis-1,2-Dichloroethene	ND	0.0005	0.0005	0.0005	0.0093	0.0054	0.0012	0.0021	0.00078	0.0015	0.0027
Dichlorodifluoromethane	ND	0.0005	0.0005	0.0005	0.0005	0.00076	0.0005	0.0007	0.001	0.0014	0.0013
1,1-Dichloroethane	ND	0.0005	0.0005	0.0005	0.0005	0.00085	0.00074	0.0016	0.0029	0.0024	0.0024
1,2-Dichloropropane	ND	0.0005	0.0005	0.0005	0.00072	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Tetrachloroethene (PCE)	Non-Norm	0.00074	0.0005	0.0005	0.0023	0.0062	0.0018	0.0029	0.0026	0.0072	0.0061
Toluene	Non-Norm	0.0047	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
1,1,1-Trichloroethane	Non-Norm	0.0051	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Trichloroethene (TCE)	ND	0.0005	0.0005	0.0005	0.0005	0.0019	0.00059	0.00079	0.00073	0.0014	0.0019
Trichlorofluoromethane	ND	0.0005	0.0005	0.0005	0.0005	0.00086	0.00086	0.0005	0.0005	0.0005	0.0005
m+p Xylene	Non-Norm	0.034	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
O-Xylene	Non-Norm	0.168	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Total Xylene	Non-Norm	0.288	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005

(1) Normality was calculated using the Shapiro-Francia test. (Non-detects replaced with 1/2 detection limit.)

Norm (X%) = data normally distributed at X% level of significance.

In-Norm (X%) = data In-normally distributed at X% level of significance.

Non-Norm = data not normally or In-normally distributed at 95% or 99% level of significance.

ND = all background data below detection limits. Value shown is the detection limit.

(2) Inter-well prediction limits calculated as follows with non-detects replaced with 1/2 detection limit:

Normal or In-normal distribution: parametric prediction interval (99% one-sided, two-sided for pH)

Non-normal distribution: non-parametric prediction interval (99% one-sided, two-sided for pH)

ND: any detectable concentrations in compliance wells are considered significant.

Bold values indicate statistically significant results.

NA - not analyzed

TABLE 4-5. RESULTS OF TREND ANALYSES

Parameter	Downgradient well									
	HL-90-2	HL-90-3	EPA-1	MPC-1	MPC-2	HL-99-1	HL-99-2	HL-99-3	HL-10-1	
Mercury (Dissolved)										
Cis-1,2-Dichloroethene			No Trend	Increasing	Increasing	No Trend	Increasing	Increasing	Increasing	
Dichlorodifluoromethane				Decreasing		Decreasing	No Trend	Decreasing	No Trend	
1,1-Dichloroethane				Decreasing	No Trend	No Trend	Increasing	No Trend	Increasing	
1,2-Dichloropropane			Decreasing							
Tetrachloroethene (PCE)			Decreasing	No Trend	Increasing	Decreasing	No Trend	Decreasing	No Trend	
Trichloroethene (TCE)				No Trend	Increasing	Increasing	Increasing	No Trend	Increasing	
Trichlorofluoromethane				No Trend						

Mann-Kendall trend analysis with non-transformed data. All non-detects replaced with zero.

Grayed boxes did not have downgradient exceedances of the respective inter-well prediction interval and therefore a trend analysis was not performed.

increasing TCE trends, the concentrations of TCE in these wells are all well below the MCL of 0.005 mg/L. Decreasing trends are evident in dichlorodifluoromethane in wells MPC-1, HL-99-1, and HL-99-3; 1,1-dichloroethane in well MPC-1; 1,2-dichloropropane in well EPA-1; and PCE in wells EPA-1, HL-99-1, and HL-99-3.

4.4 TEMPORAL CONCENTRATION PLOTS

This report focuses on concentration trends for PCE and nitrate because they are the only constituents currently exceeding their MCLs in downgradient monitoring wells. PCE was also the focus of the Corrective Measures Assessment for the landfill (Hydrometrics, 1995).

In an attempt to reduce concentrations of PCE in compliance well HL-90-1, the City installed a groundwater extraction system in the spring of 2000 (Hydrometrics, 1999b). This treatment system involves pumping wells HL-99-1, HL-99-2, and HL-99-3 to intercept PCE leaving the landfill, and treating the water to remove VOCs prior to land application on Bill Roberts Golf Course. These wells have been included in groundwater monitoring events along with compliance well HL-90-1, now replaced by HL-10-1, to evaluate the progress of this new groundwater extraction system. Trends in PCE concentrations over time since the groundwater extraction system was installed for selected monitoring wells are shown on Figure 4-1. PCE concentrations exceeded the MCL value of 0.005 mg/L in monitoring wells HL-10-1, MPC-1, and HL-99-3 for June 2016.

Historically, the concentration of PCE in well MPC-1 (now 0.0062 mg/L) has fluctuated between 0.0032 mg/L and 0.017 mg/L based on data collected between May 1992 and June 2016 and according to the trend analysis discussed in the previous section, is neither increasing nor decreasing with time. There was an increasing trend in well MPC-2 beginning in June 2011 through June 2014 that now appears to be decreasing and has so far remained below the MCL. The PCE concentrations in pumping wells HL-99-1, HL-99-2, and HL-99-3 have shown seasonal fluctuations and decreasing trends in HL-99-1 and HL-99-3 since their installation in 1999. Concentrations in well EPA-1 have decreased significantly since monitoring began (>90 ppb) and have been below the MCL since December 1999.

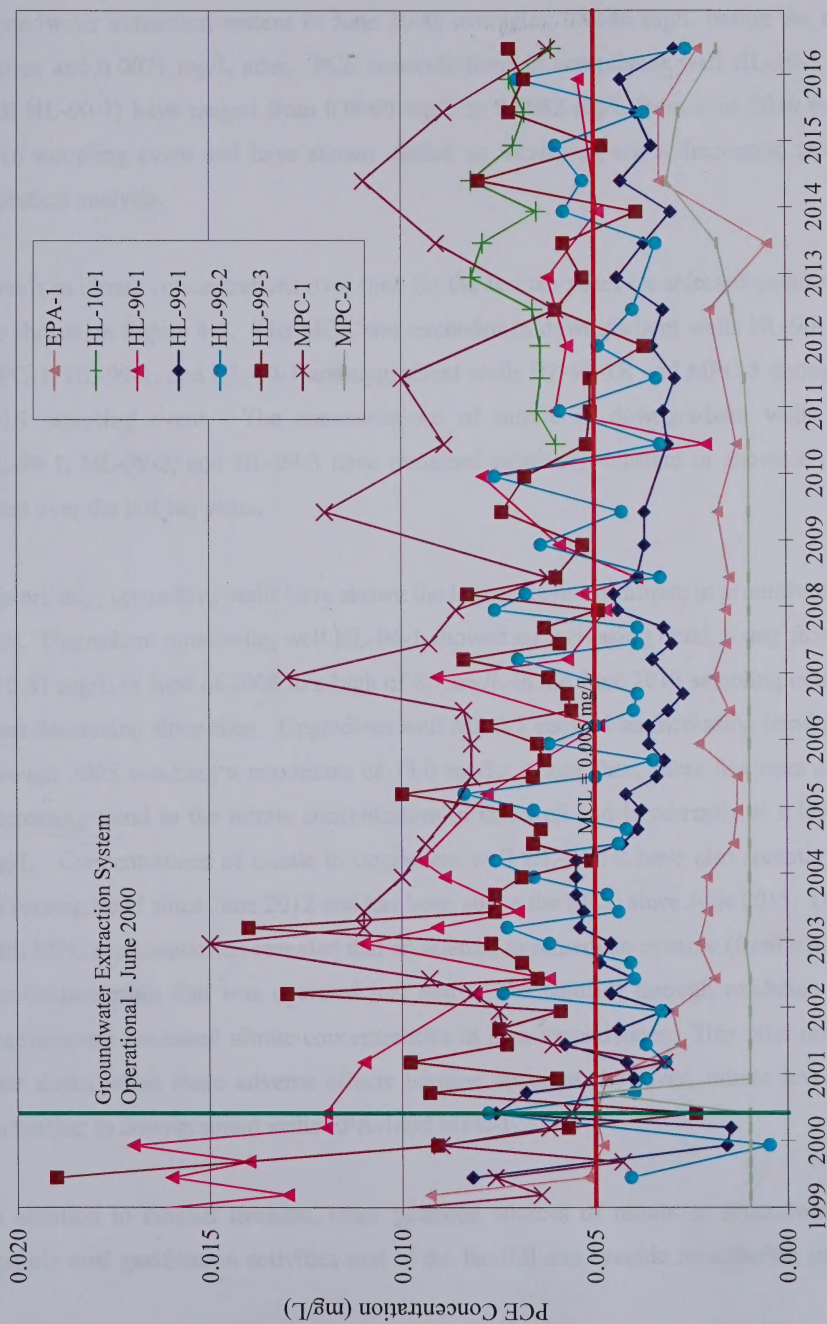


Figure 4-1. Temporal Trends in Tetrachloroethene Concentrations at Selected Monitoring Wells

Compliance well HL-90-1 has shown definite improvement since the installation of the groundwater extraction system in June 2000, averaging 0.0146 mg/L before the extraction system and 0.0071 mg/L after. PCE concentrations in compliance well HL-10-1 (replaced well HL-90-1) have ranged from 0.0060 mg/L to 0.0082 mg/L from June 2010 to the June 2016 sampling event and have shown neither an increasing nor a decreasing trend during statistical analysis.

Trends in nitrate concentrations over time for the last ten years for selected monitoring wells are shown on Figure 4-2. The MCL was exceeded in downgradient wells HL-90-3, EPA-1, MPC-1, HL-99-1, and HL-10-1 and upgradient wells HL-94-1R and MPC-5 during the June 2016 sampling event. The concentrations of nitrate in downgradient wells HL-90-3, HL-99-1, HL-99-2, and HL-99-3 have remained relatively constant or shown a decreasing trend over the last ten years.

Historically, upgradient wells have shown the highest levels of nitrate in groundwater (Figure 4-2). Upgradient monitoring well HL-06-1 showed an increasing trend, rising from a low of 0.81 mg/L in June of 2008 to a high of 8.7 mg/L in the June 2013 sampling event, but has been decreasing since then. Upgradient well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 73.0 mg/L. Since then, there has been a generally decreasing trend in the nitrate concentration in this well and is currently at a level of 31.0 mg/L. Concentrations of nitrate in upgradient well HL-94-1R have also recently shown an increasing trend since June 2012 and has been above the MCL since June 2015. Discussions with MPC representatives revealed that an attempt to remediate cyanide (from a historic coal gasification plant that was operated just east of the landfill) through oxidation may have inadvertently increased nitrate concentrations in area groundwater. This pilot program was shut down when these adverse effects became apparent; however, nitrate levels are still increasing in downgradient wells EPA-1 and MPC-1.

In addition to landfill leachate, other potential sources of nitrate in groundwater include historic coal gasification activities east of the landfill and cyanide remediation activities for

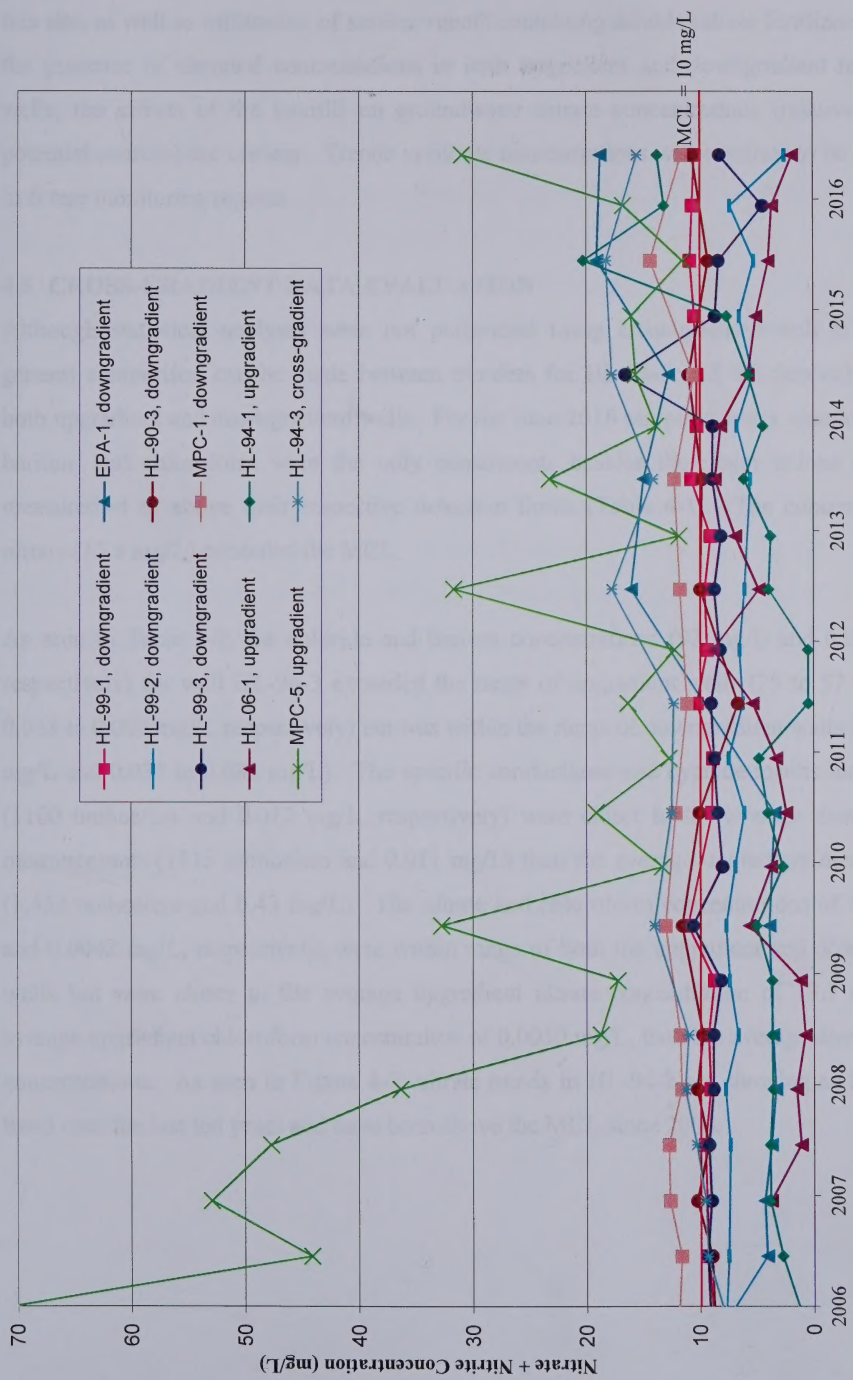


Figure 4-2. Temporal Trends in Nitrate Concentrations at Selected Monitoring Wells

this site, as well as infiltration of surface runoff containing soluble nitrate fertilizers. Due to the presence of elevated concentrations in both upgradient and downgradient monitoring wells, the effects of the landfill on groundwater nitrate concentrations (relative to other potential sources) are unclear. Trends in nitrate concentrations will continue to be evaluated in future monitoring reports.

4.5 CROSS-GRADIENT DATA EVALUATION

Although statistical analyses were not performed using cross-gradient well HL-94-3, a general comparison can be made between the data for HL-94-3 and the data collected for both upgradient and downgradient wells. For the June 2016 sampling event, cyanide, nitrate, barium, and chloroform were the only constituents besides the major anions that were measured at or above their respective detection limits (Table 4-1). The concentration of nitrate (15.6 mg/L) exceeded the MCL.

As seen in Table 3-2, the chloride and barium concentrations (92 mg/L and 0.081 mg/L, respectively) for well HL-94-3 exceeded the range of upgradient wells (25 to 57 mg/L and 0.038 to 0.069 mg/L, respectively) but was within the range of downgradient wells (27 to 169 mg/L and 0.035 to 0.082 mg/L). The specific conductance and cyanide results for HL-94-3 (1100 umhos/cm and 0.012 mg/L, respectively) were closer to the average downgradient measurements (1315 umhos/cm and 0.011 mg/L) than the average upgradient measurement (1,432 umhos/cm and 0.43 mg/L). The nitrate and chloroform concentrations of 18.3 mg/L and 0.0042 mg/L, respectively, were within range of both the upgradient and downgradient wells but were closer to the average upgradient nitrate concentration of 13.7 mg/L and average upgradient chloroform concentration of 0.0050 mg/L, than the average downgradient concentrations. As seen in Figure 4-2, nitrate trends in HL-94-2 are showing an increasing trend over the last ten years and have been above the MCL since 2006.

5. IRRIGATION WELL AND DOMESTIC WELL DATA EVALUATION

One irrigation well (I-4), the infiltration gallery and eight domestic wells (5, 16, 40, 48, 52, 57, 62, and 90) were included in the June 2016 sampling event. Wells 52 and 90 could not be sampled due to scheduling conflicts with the homeowners. Due to the lower laboratory detection limits, more VOC constituents were detected than historically. The infiltration gallery had no VOCs reported above the detection limits. All other wells in this group contained detectable concentrations of chloroform. All of the domestic wells with the exception of well 62 had detectable concentrations of PCE. Wells 5 and I-4 had detectable concentrations of 1,1-dichloroethane. Wells 16, 40, and I-4 had detectable concentrations of dichlorodifluoromethane. Wells 40 and I-4 had detectable concentrations of cis-1,2-dichloroethene and wells 5 and I-4 had detectable concentrations of TCE. With the exception of PCE in I-4 (0.0062 mg/L compared with MCL of 0.005 mg/L), all detections of VOCs were below their respective MCLs. Concentrations of PCE in I-4 have historically fluctuated between 0.0036 mg/L and 0.011 mg/L.

Trends in PCE concentrations over the last ten years for the sampled domestic and irrigation wells are shown on Figure 5-1. Most of these wells are showing generally decreasing trends with time. Well 16 shows a slight increasing PCE trend since June 2013, but has historically ranged from 0.0036 mg/L to 0.011 mg/L from May 1997 to present and is currently within the historical range. All of these wells are used only for irrigation and all homeowners of these domestic wells have been connected to the City water supply.

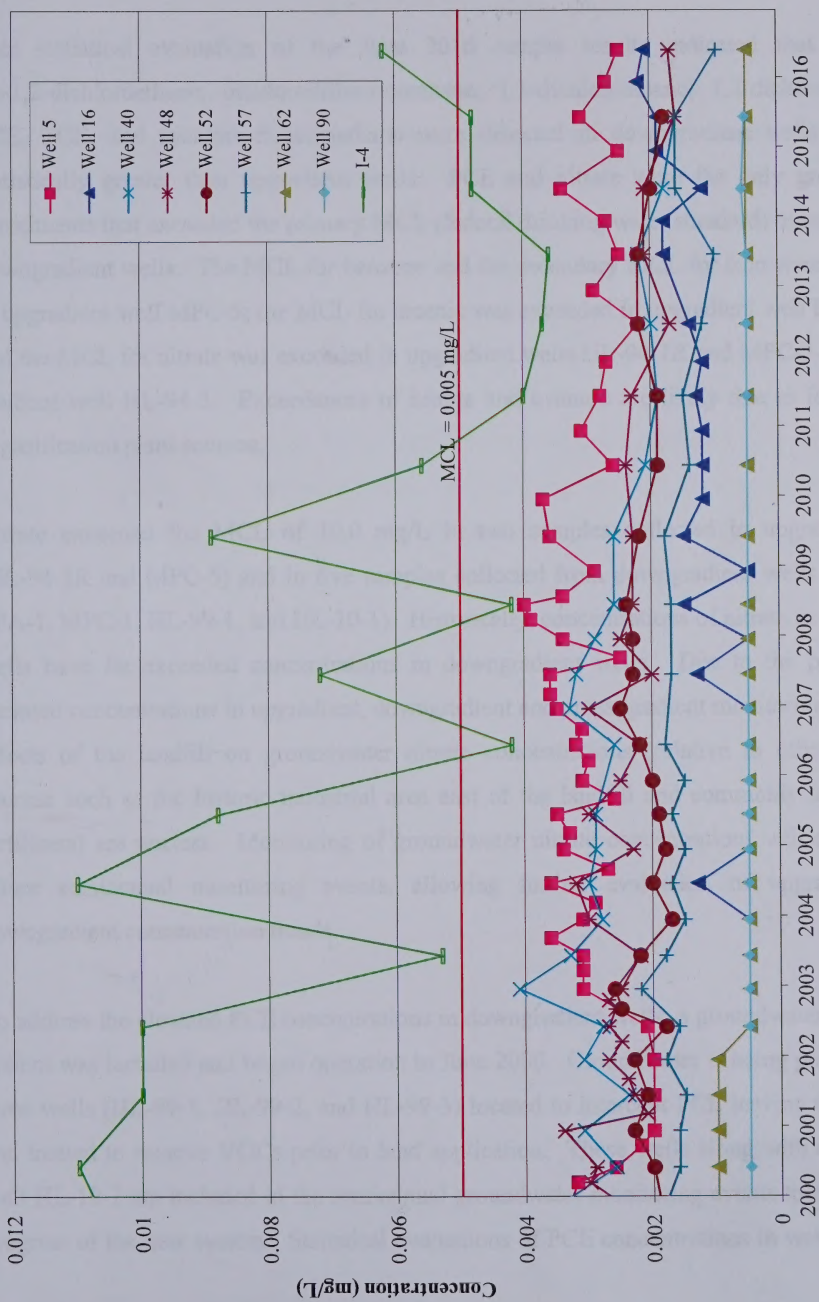


Figure 5-1. Temporal Trends in PCE Concentrations in Domestic and Irrigation Wells

6. SUMMARY AND CONCLUSIONS

This statistical evaluation of the June 2016 sample results indicated that mercury, cis-1,2-dichloroethene, dichlorodifluoromethane, 1,1-dichloroethane, 1,2-dichloropropane, PCE, TCE, and trichloro-fluoromethane were detected in downgradient wells at levels statistically greater than upgradient wells. PCE and nitrate were the only groundwater constituents that exceeded the primary MCL (federal drinking water standard) in one or more downgradient wells. The MCL for benzene and the secondary MCL for iron were exceeded in upgradient well MPC-5; the MCL for arsenic was exceeded in upgradient well HL-94-2R; and the MCL for nitrate was exceeded in upgradient wells HL-94-1R and MPC-5 and cross-gradient well HL-94-3. Exceedances of nitrate and cyanide are likely due to former coal degasification plant sources.

Nitrate exceeded the MCL of 10.0 mg/L in two samples collected in upgradient well (HL-94-1R and MPC-5) and in five samples collected from downgradient wells (HL-90-3, EPA-1, MPC-1, HL-99-1, and HL-10-1). Historically, concentrations of nitrate in upgradient wells have far exceeded concentrations in downgradient wells. Due to the presence of elevated concentrations in upgradient, downgradient and cross-gradient monitoring wells, the effects of the landfill on groundwater nitrate concentrations (relative to other potential sources such as the historic industrial area east of the landfill and commonly used nitrate fertilizers) are unclear. Monitoring of groundwater nitrate concentrations will continue in future semiannual monitoring events, allowing further evaluation of upgradient and downgradient concentration trends.

To address the elevated PCE concentrations in downgradient wells, a groundwater extraction system was installed and began operation in June 2000. Groundwater is being pumped from three wells (HL-99-1, HL-99-2, and HL-99-3) located to intercept PCE leaving the landfill, and treated to remove VOCs prior to land application. These wells along with compliance well HL-10-1 are included in the semiannual groundwater monitoring events to evaluate the progress of the new system. Statistical evaluations of PCE concentrations in wells HL-99-1

and HL-99-3 show a decreasing trend; concentrations in wells HL-99-2 and compliance well HL-10-1 show neither an increasing nor decreasing trend.

PCE exceeded the federal MCL in downgradient wells MPC-1, HL-99-3 and HL-10-1. According to the potentiometric map in Figure 2-2, groundwater flow through well MPC-1 generally heads towards the groundwater extraction well where it can be extracted and treated. Concentrations of PCE in extraction wells HL-99-1 and HL-99-3 show a statistically decreasing trend. Well HL-10-1 was installed in May 2010 immediately adjacent to but deeper than compliance well HL-90-1. The concentration of PCE in well HL-10-1 is within historical range of HL-90-1 concentrations and near the MCL (0.0061 mg/L compared to the MCL of 0.005 mg/L). It is predicted that PCE concentrations in HL-10-1 should continue to be stable or decrease as assumed finite upgradient sources are diminished. Downgradient of HL-10-1, irrigation well I-4 and domestic wells 5, 40, 48, and 57 also show generally decreasing trends since the installation of the groundwater extraction system.

7. REFERENCES

- EPA, 1989. Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities - Interim Final Guidance, PB89-151047, February 1989.
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- Hydrometrics, Inc., 2008. Revised Sampling and Analysis Plan, City of Helena Landfill, Groundwater, Surface Water and Landfill Gas Monitoring Activities, Prepared for City of Helena, March 2008.

**DATA VALIDATION REPORT
CITY OF DELANA LANDFILL**

Environmental Monitoring, Inc.
June 2016
West Chester, Pennsylvania

APPENDIX A

DATA VALIDATION REPORT

Prepared by
Environmental, Inc.
2000 Delaware Avenue
Wilmington, DE 19801

JULY 2016

DATA VALIDATION REPORT CITY OF HELENA LANDFILL

Groundwater Samples Collected in

June 2016

(Semi-Annual Sampling)

Prepared by
Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

JULY 2016

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GLOSSARY OF TERMS

CCB.....	Continuing Calibration Blank
CCV	Continuing Calibration Verification
CLP	Contract Laboratory Program
CRDL.....	Contract Required Detection Limit
FAA	Flame Atomic Absorption
GFAA.....	Graphite Furnace Atomic Absorption
HGAA.....	Hydride Generation Atomic Absorption
ICB.....	Initial Calibration Blank
ICP	Inductively Coupled Plasma
ICV.....	Initial Calibration Verification
IDL.....	Instrument Detection Limit
LCS	Laboratory Control Sample
MSA.....	Method of Standard Additions
PB.....	Preparation Blank
PRDL	Project Required Detection Limit
QAPP	Quality Assurance Project Plan
QC.....	Quality Control
RPD.....	Relative Percent Difference
RSD.....	Relative Standard Deviation
SOW.....	Statement of Work
TDS	Total Dissolved Solids

SUMMARY

Laboratory analysis for groundwater samples collected for the June 2016 sampling event as part of the City of Helena Landfill have been reviewed and validated. This review has been in accordance with the "Revised Sampling and Analysis Plan; City of Helena Landfill; Groundwater, Surface Water, and Landfill Gas Monitoring Activities" (Hydrometrics, March 2008). All samples were analyzed at Energy Laboratories in Helena, Montana.

Data results are qualified when associated field quality control samples have not met validation criteria. Not all quality control deficiencies are equally serious and some may not have any practical impact on the usefulness of the data. A summary of quality control violations found in this validation follows:

Violations involving field quality control samples:

- It should be noted that the wells were not sampled in the order listed in the SAP. The order of sampling was followed for all wells that do not use dedicated or disposable equipment. Any variances in sampling order were noted in the field book or sampling forms.

Violations involving laboratory quality control samples:

- In the QA/QC Summary Reports provided by Energy Laboratories, there were several QA/QC exceedances. However, at this level of validation, laboratory exceedances are noted but no flagging of the data occurs.
- It should be noted that the reporting limits used for all metals analysis varied from the requested limits however the RLs used were lower than the requested limits, and did not seem to impact the results of the analysis.
- It should be noted that Energy Laboratories used a different method than stated in the work plan on the following parameters: pH, SC, cyanide and all dissolved metals. However, no associated data was flagged because the methods used are considered comparable to stated methods in the work plan.
- Energy Laboratories exceeded the holding time for pH for all samples submitted. However, as a rule holding times for laboratory pH measurements are frequently exceeded because measurements are typically not conducted "immediately", but rather as soon as practicable. Therefore, no qualifiers are applied for lab pH holding time exceedances.
- Due to laboratory error, the following samples were analyzed outside of the method recommended holding time for cyanide: Sample H16060123-020D; Test CN-W-T-PR:

The prep hold time was exceeded by 0.875 days. Sample H16060123-022D: Test CN-W-T-PR: The prep hold time was exceeded by 0.170 days. A laboratory data flag was applied to the samples noted to note analysis performed past recommended holding time (H).

Deviations from the prescribed quality control procedures and/or exceedances of quality control limits have been noted, and results have been flagged in the database. The data quality objectives for accuracy and precision were met, as 100 percent of the field quality control sample results were within control limits and 98 percent of the laboratory quality control samples were within limits. The frequency requirements of 10 percent submittal of blanks, duplicates, control standards and spikes were met. The recommended project completeness goal, acceptance of 90 percent of the results as valid, has also been met as no results have been rejected as a result of this review. Further discussion of data quality objectives is in Section 12 of the data validation report. All tables are in Appendix 1: data validation codes and definitions are listed in Table 1; and a historical comparison is in Table 2. A database printout of this sampling event is located in Appendix 2. The Hydrometrics field notes are in Appendix 3. Energy Laboratories Analytical Reports are located in Appendix 4.

DATA VALIDATION REPORT

1. INTRODUCTION

This validation applies to organic and inorganic analyses for 30 water samples collected for the City of Helena Landfill semi-annual monitoring project during the June 2016 sampling event. The total number of samples included: one field duplicate, two field blanks (DI and Rinsate), three trip blanks, twenty-three non-QC water samples and one field observations.

All samples were submitted for volatile organic analyses, and select samples were submitted for inorganic analyses (metals and wet chemistry) as follows:

SITE CODE	SAMPLE NUMBER	WATER LEVEL	FIELD PARAMETERS ¹	METALS / COMMONS ²	VOLATILES METHOD 8260 ³
INF GALLERY	HL-1606-100	X	X		X
MPC-2	HL-1606-101	X	X		X
#90	HL-1606-123	NO SAMPLE – POWER OFF			
Rinsate Blank	HL-1606-112			X	X
D.I. Blank	HL-1606-122			X	X
MPC-5	HL-1606-121	X	X	X	X
#52		NO ACCESS			
I-4	HL-1606-114		X		X
#5	HL-1606-113		X		X
HL-99-1	HL-1606-118	X	X	X	X
HL-90-2	HL-1606-102	X	X	X	X
HL-06-1	HL-1606-105	X	X	X	X
HL-90-3	HL-1606-106	X	X	X	X
HL-90-3 DUP	HL-1606-107			X	X
HL-94-1R	HL-1606-103	X	X	X	X
HL-94-2R	HL-1606-108	X	X	X	X
HL-94-3	HL-1606-104	X	X	X	X
EPA-2	HL-1606-128	X			
#57	HL-1606-117		X		X
EPA-4	HL-1606-129	X			
MPC-1	HL-1606-110	X	X	X	X
EPA-1	HL-1606-111	X	X	X	X
#62	HL-1606-124		X		X
#48	HL-1606-116		X		X
HL-10-01	HL-1606-109	X	X	X	X
#16	HL-1606-125		X		X
HL-99-3	HL-1606-120	X	X	X	X
#40	HL-1606-115		X		X
TRIP BLANK	TB 5583				X
TRIP BLANK	TB 5597				X
TRIP BLANK	TB 4526				X
HL-99-2	HL-1606-119	X	X	X	X
I-1	HL-1606-130	X			
82-3	HL-1606-127	X			
#61	HL-1606-126		X		X

1.) Field parameters include pH, SC, and water temperature.

2.) Metals and commons include those compounds listed in the first half of ARM 17.50.708 Table 1.

3.) Volatile organic compounds include those listed in the second half of ARM 17.50.708 Table 1.

- Validation procedures used are generally consistent with:

(Check all that apply)

- ☒ EPA CLP National Functional Guidelines for Inorganics Data Review
- ☒ EPA CLP National Functional Guidelines for Organic Data Review
- ☒ Work Plan (Sampling and Analysis Plan, City of Helena Landfill Groundwater Monitoring Activities, Hydrometrics, March 2008)

- Overall level of validation:

- ☐ Contract Laboratory Program (CLP)
- ☒ Standard (see following Notes)
- ☐ Visual

Notes: The review of this data includes checking all field and laboratory quality control samples; flagging for exceedances in field quality control; and calculating precision, accuracy, and completeness for both laboratory and field quality control samples.

2. DELIVERABLES

- All laboratory document deliverables were present as specified in the CLP-Statement of Work (CLP-SOW), EPA, 1993 and/or the project contract.

☒ Yes (see following notes)
☐ No

- All documentation of field procedures was provided as required.

☒ Yes
☐ No

- Consistency with project requirements

Sampling was completed in order as stated in the SAP.

☒ Yes (see following Notes)
☐ No

Notes: It should be noted that the wells were not sampled in the order listed in the SAP. The order of sampling was followed for all wells that do not use dedicated or disposable equipment. Any variances in sampling order were noted in the field book.

3. FIELD QUALITY CONTROL SAMPLES

- Field blanks

Please note that the highest blank value associated with any particular analyte is the blank value used for the flagging process.

DI, trip, rinsate, or any other field blanks have been carried out at the proper frequency.

☒ Yes
☐ No

Reported results on the field blanks are less than the contract required detection limits (CRDL) or the project required detection limits (PRDL) if project detection limits have been specified.

☒ Yes
☐ No

- **Field duplicates**

Field duplicates have been collected at the proper frequency.

☒ Yes

☐ No

Field duplicate relative percent differences (RPD's) were within the required control limits (RPD of 20 percent or less for water matrix, 35 percent or less for soil matrix). If the sample or duplicate result is less than 5 times the PRDL, the RPD criteria are not used. In these cases, the difference between the sample and the duplicate results must be within $\pm$ the PRDL for water matrix, within ± 2 times the PRDL for soil matrix.

☒ Yes

☐ No

- **Field standards**

Field standards were sent at the proper frequency

☐ Yes

☐ No

☒ NA - Not required by the work plan.

4. LABORATORY PROCEDURES

- **Laboratory procedures followed**

☐ CLP-SOW

☒ SW-846

☒ Methods for Chemical Analysis of Water and Wastes

☐ XRF Standard Operating Procedures

☐ Other

- **Samples were received by the laboratory at the proper temperature**

☒ Yes

☐ No

- **Holding times met**

☐ Yes

☒ No (see the following Notes)

Notes: Energy Laboratories exceeded the holding time for pH for all samples submitted. However, as a rule holding times for laboratory pH measurements are frequently exceeded because measurements are typically not conducted "immediately", but rather as soon as practicable. Therefore, no qualifiers are applied for lab pH holding time exceedances in the database.

Due to laboratory error, the following samples were analyzed outside of the method recommended holding time for cyanide: Sample H16060123-020D; Test CN-W-T-PR: The prep hold time was exceeded by 0.875 days. Sample H16060123-022D: Test CN-W-T-PR: The prep hold time was exceeded by 0.170 days. A laboratory data flag was applied to the samples noted to note analysis performed past recommended holding time (H).

- **Consistency with project requirements**

Analyses were carried out as requested.

X Yes (see following Notes)

No

Project specified methods were used.

X Yes (see following Notes)

No

Notes: Energy Laboratories used a different method than stated in the work plan on the following parameters: pH, SC, cyanide and all dissolved metals. However, no associated data was flagged because the methods used are considered comparable to stated methods in the work plan.

5. DETECTION LIMITS

- Reporting detection limits met project required detection limits (PRDL).

X Yes (see following Notes)

No

Notes: The reporting limits used for all metals analysis varied from the requested limits however the RLs used were lower than the requested limits, and did not seem to impact the results of the analysis. Various samples analyzed for nitrate + nitrite as n and cyanide were flagged with a D by the laboratory to indicate the reporting limit was increased due to sample matrix; this also did not impact results.

6. LABORATORY BLANKS

Please note that the highest blank value associated with any particular analyte is the blank value used for the flagging process.

- **Preparation/Method blanks**

Preparation/Method blanks were prepared and analyzed at the required frequency.

X Yes

No

All analytes in the preparation blank were less than the CRDL (or PRDL if a project detection limit has been specified).

X Yes

No

7. LABORATORY BLANK SPIKES

- **Blank Spikes**

Blank spikes (organics) were prepared and analyzed at the required frequency.

X Yes

No

Blank spike recoveries were within control limits.

☒ Yes

☐ No

8. SURROGATE SPIKES

Surrogate spikes were prepared and analyzed at the required frequency.

☒ Yes

☐ No

Surrogate spike recoveries were within control limits.

☒ Yes

☐ No

9. MATRIX SPIKE /MATRIX SPIKE DUPLICATES (MS/MSD)

- Matrix spike samples were analyzed at the proper frequency.

☒ Yes

☐ No

Matrix spike recoveries were within control limits.

☐ Yes

☒ No (see following Notes)

Notes: Several matrix spike and matrix spike duplicate samples contained QC exceedances. At this level of validation, these exceedances are only noted and no associated data is qualified.

- Matrix spike duplicate samples were analyzed at the proper frequency.

☒ Yes

☐ No

Matrix spike duplicate RPD's were within control limits.

☐ Yes

☒ No (see following Notes)

Notes: Several matrix spike and matrix spike duplicate samples contained QC exceedances. At this level of validation, these exceedances are only noted and no associated data is qualified.

10. INTERPARAMETER RELATIONSHIPS

- The following relationships have been checked for all data from the June2016 monitoring:

☒ Lab SC versus field SC

☒ Lab pH versus field pH

Lab SC versus field SC: A comparison of the field and lab SCs using a percent difference (%D) criteria for evaluation purposes. For this data set, the data were all found to be within acceptable limits.

Lab pH versus field pH: A comparison of the field and lab pHs using a percent difference (%D) criteria for evaluation purposes. For this data set, the data were all found to be within acceptable limits.

11. HISTORICAL COMPARISON

Current sampling event data (June 2016) were compared to historical data. The data for the June 2016 sampling event compared well to the historic data.

12. DATA QUALITY OBJECTIVES

- Project data quality objectives (DQO's) met.

X Yes

 No

Accuracy

Accuracy for this project is the agreement between a measured value and a true value and is measured by the recoveries on the laboratory matrix spikes and laboratory control samples.

Accuracy for this sampling event was 99 percent.

Precision

Precision for this project is the degree of variability between duplicate measurements. Laboratory analytical variability is measured by laboratory duplicates; field duplicates are a measure of overall variability in both field sampling and laboratory techniques.

Laboratory precision was 98 percent for this sampling event.

Field precision was 100 percent for this sampling event.

Completeness

The target completeness for this project is 90 percent of the measurements valid (not rejected). This percentage is based on the number of valid measurements compared to the number of planned measurements. Completeness for this sampling event was 100 percent.

DATA VALIDATION REPORT

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Reviewed by: Jodi Bingham, P.E.

REFERENCES

- Hem, J.D., 1992. Study and Interpretation of the Chemical Characteristics of Natural Water, 3rd Edition. US Geological Survey Water Supply Paper 2254.
- Hydrometrics Project Work Plan. Sampling and Analysis Plan City of Helena Landfill Groundwater Monitoring Activities, March 2008.
- U.S. Environmental Protection Agency, 1990. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition.
- U.S. Environmental Protection Agency, 1993. USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review. October 2004.
- U.S. Environmental Protection Agency, 1994. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. October 2004.

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APPENDIX B

STATISTICAL ANALYSIS REPORTS

Data Validation and
Evaluation of June 2016
Groundwater Quality Data

City of Helena Landfill

Appendix B - Statistical Analyses Reports

August 2016



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